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A Conceptual Paper on Critical Review of Recycling of Electronic Waste (E-Waste)

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ABSTRACT : *Electronic waste (e-waste) poses a great potential for accumulation of solid waste globally. It's one of the fastest growing pollution problems worldwide. It has substantial varieties of harmful substance which can pollute the environment and affects human health if not dispose properly or recycle in an appropriate scientific manner. Recycling electronic waste is now receiving the desired attention globally. Recycling electronics recovers valuable materials and as a result, we reduce greenhouse emissions, reduces pollutions, save energy and resources by extracting fewer materials from earth. The successful strategy for curtailing the effects of e-waste is to develop appropriate management strategies through the development of eco-friendly devices, proper collection, and recovery and recycle materials by the best safe methods.*

KEYWORDS: *E-waste, Recycling, Toxic substance, Environment*

I. INTRODUCTION

The growing quantity of e-waste from the electronic industry is beginning to reach an alarming proportion (Wath el., 2011) which if left unchecked may have a disastrous consequence on our environment and Human health. Available evidence abound to indicate that E- waste equals 1-3% of total solid waste worldwide (Robinson, 2009. UNEP, 2007).The quantity of e-waste produced is not only from the developed nations, but even the developing countries contributes their own fair share of e-waste and waste from electronic and electrical equipment(WEEE).Available information indicate that as far back as 2006,over 80% of the e-waste produced by the developed countries are been exported to poor or developing countries of the world(Schmidth.,2006).Nigeria is one of such countries and is ranked among the top ten(10) importer of e-waste globally with India, Pakistan, Vietnam, The Philippines, Malaysia and Ghana where e-waste and WEEE are been dumped indiscriminately without concern for its effects on the environment and health impact (Robbinson ,2009).

Today the electronic waste recycling business in all area of the developed world is a large and rapidly consolidating business. Recycling raw materials from end-of –life of electronic is the most effective and efficient solution to the ever growing e-waste problem. Electronic products are mainly made from valuable resources and highly engineered materials, including metals, plastics and glass, all of which requires energy to mine and manufacture them. Reusing and recycling consumer electronics conserves our natural resources and avoid air and waste pollutions as well as greenhouse gas (GHG) emissions that are caused by manufacturing virgin materials. The e-waste is normally referring to consumer electronic equipments that is no longer wanted-waste includes computers, printers, televisions, VCRs, cell phones, fax machines, stereo and electronic games. Electronic are generally known to contain various elements such as lead, copper and other heavy metals or generally referred to as toxic substances. The use of electronic products has grown substantially over the past few decades, changing the way and the speed in which we communicate and how we get information's and entertainments. Electronic waste poses a great potential for accumulation of solid waste globally. It's one of the fastest growing pollution worldwide. It has substantial varieties of harmful substances which can pollute the environment and affects human health if not dispose properly or recycle in an appropriate manner. The successful strategy for curtailing the effects of e-waste is to develop an appropriate management strategy through the development of eco-friendly devices, proper collections, recovery and recycle materials by the best safest methods. Electronics are complex devices which are made of a wide range of materials. Some of the constituent elements such as lead, copper, nickel, cadmium and mercury could pose risks to human health or the environment if mismanaged at their end-of –life.

Recycling electronics recovers valuable materials and as a result, we reduce greenhouse gas (GHG) emissions, reduce pollution, save energy and resources resulting in a sustainable practice. Recycling when wireless devices reach their end-of –life .Responsible recycling entails best management practices of the electronic being recycle, worker health and safety ensured and environmental consideration.

However e-waste generation in some developing countries are insignificant when compared to the developed countries of the world, but the major a confronting the developing nations are the issue of e-waste being dump at the yard of these developing countries. According to Hicks et al (2005), almost 80 percent of all e-waste in developed countries are being exported to developing countries. Environmentalist and other conscious individual and corporate organizations concerns now is not just how much quantities of e-waste are imported to developing countries, but the large range of toxic chemicals associated with such e-waste is the issue of concern. The paper seeks to examine e-waste, the risk associated with it to human health and the environment, the recycling of e-waste as an effective and efficient e-waste management strategy.

II. LITERATURE REVEIW

Electronic waste popularly referred to as e-waste are consumer electronic equipment that are no longer wanted and discarded .They include computers, printers, televisions, cell phones, fax machines, stereo, games among others. They arise from discarded electronics gadgets. However, electronic gadgets are meant to improve our quality of lives, but they equally have some negative impact on human health and the environment. They contain toxic chemicals and as such, their disposal at the end- of –life requires a specialized approach. The uses of electronic gadgets have substantially increased in the past few decades and this is commensurable to the quantity of e-waste being disposed which is expanding exponentially. E-waste is an emerging problem globally given the volume of e-waste being generated and the content of both toxic and valuables materials in them. Substantial evidences abound to show that the fast growing waste stream would continue to increase because of the global markets for personal computers (PC) is far from being saturated and the average lifespan of a PC is decreasing rapidly. The life span of a central processing unit (CPU) has reduced from 4 to 6 years in 1997 to 2years in 2005(culver, 2005).

Rapid economic growth, improved quality of life and access to consumer electronic goods has resulted in the increased consumption and production of electrical and electronic equipment (EEE) globally according to Balabanic et al (2013).E-waste is a serious problem at both local and international arena. it was initially though as a problem of the developed countries, but with the prevailing scenario, It is a problem for both developed and developing countries of the world. The volume and magnitude of e-waste is growing exponentially because of consumer technology is rapidly changing and the innovations of technology results in increased obsolensce, thereby increasing the quantities and volume of e-waste at the global scale. E-waste is known to contain many different materials, some of which contains a variety of toxic substances that can contaminate the environment and threaten human health as observed by Zhana and Forsberg (1997). New technologies are rapidly happening and resulting in millions of analogue appliances leading to their disposal in landfill and dumpsites despite their potential negative impact on the environment. The global consistent advent of new designs “smart” functions and technology in the last decades is resulting in the rapid obsolescence of many electronic items.

Consequently, the lifespan of many electronic goods has being substantially shortened due to advancement in electronics, attractive consumer designs and marketing and compatibility issues. (Widmer et al., 2005).E- waste disposal impact on human health and the environment is an issue of great concern globally as posited many researchers(Wang et al.,2009,Xing et al.,2009,Zheng et al.,2008.).E- Waste disposal method includes among others landfill and incinerations, both of which pose a considerable risk and contamination to the environment. Various researchers such as Puckett and Smith,(2002) have stated that there are more than one thousand toxic substance associated with e- waste besides the commonly known such as Barium(Ba), Beryllium(Be),Cadmium(Cd), Cobalt(Co),Chromium(Cr), Copper(Cu), Iron(Fe), Lead(Pb) among others-waste disposal impacts on human health which include through food chain issues and direct impact on workers who labor in primitive recycling area from occupational exposure to toxic substances. In view of this development, various researchers have substantiated a direct impact of backyard recycling on workers as commonly practiced in developing countries. Significant dangers associated with e-waste to human health both in terms of chronic and acute conditions. For instance, in a study undertaken and reported by Qu et al(2007) shows that blood, serum, hair ,scalp hair ,human milk and urine from people who lived in area where e-waste are recycled shows the presence of significant concentration of toxic substances. Numerous researchers have demonstrated that toxic metals and polyhalogenated organics including polychlorinated biphenyl(PCBS) and polybrominated diphenly ethers (PBDES) can be release from e-waste posing serious risks to human and the environment.(Zuczwa and Hites.,1984.,Rbbinson.,2009,Williams et al.,2008).A studies of previous researches on e-waste problems in developing countries and countries on transitions showed that China, Cambodia, India, Indonesia, Pakistan and Thailand and some African countries such as Nigeria receive e-waste from developed countries, although specific e-waste problems differ considerably between countries. For instance, Nigeria mainly reuse disposed electronic products whereas Asian countries dismantle those electronic waste often using

unsafe procedure.(Wong et al .,2007).Due to the pressure from environmentalist, some manufacturers of electronic goods have attempted to safely dispose of e-waste with advanced technologies in both developed and developing countries.(US government accountabilityoffice.,2008.,Widmer et al.,2005).Problems associated with e-waste have been challenged by authorities in a number of countries and concrete steps were taken to alleviate them with the introduction of management tools and legislations at national and global levels. Example of such tools includes Life-cycle-assessment (LCA), material flow analysis (MFA) and multi criteria analysis (MCA) which is now widely being practiced to manage e-waste problems and extended producer responsibility (EPR) is the regulation for e-waste management.

THE EXISTING LEGISLATIONS AND CONVENTIONS

- The derive now as articulated in the policy objectives of government is centered on Green procurement for new or used equipments, producers take back for e-waste, environmental management system and pollution control for facilities in recovery, recycling and disposal operations, finance mechanism for producers take back and governances. The Nigeria constitution of 1999 addresses all the highlighted issues under the environment protection clause (article 20) Article (20) of the constitution empowers the state to protect and improve the environment and safe guard the water, air, land, forest and wildlife of Nigeria .The government is a signatory to various conventions and treaties such as: The Basel convention of 1989 and the key conference of parties (COP) Decisions. The Basel convention initiatives are:
- To encourage private sector participation in ESM of E- waste
- The solving the e-waste (st EP) initiatives officially launched on 7th March 2007 which aims to standardize the global e-waste recycling process to harvest valuable components of WEEE, extend the life of products and market for the reuse and to harmonize world legislative and policy approaches to e-waste management and to
- The partnership for action on computing equipment
  Equally the RACE objectives are:
  To provide new and innovative approaches for addressing emerging issues on use and end –life computing equipment. Nigeria government ratified the convention in 1991.Consequently, the critical issues raises are:
- To minimize the amount and toxicity of hazardous waste generated
- Ensure environmentally sound management (ESM) as close as possible to the source of generations
- Prohibit import and export of hazardous waste
- Cooperate among parties for environmentally sound management of waste.
  There are various such agreements and conventions geared towards sustainable disposal of e-waste .The multilateral environment Agreements (MEAS) to which Nigeria is a party includes:
- Basel convention on trans boundary movements of hazardous waste and its disposal of 1992(party ratified in1990)
- Ban Amendment (ratified in 2004)
- Bamako convention o the ban of the import into Africa and control of trans boundary movement and management of hazardous wastes within Africa (1991)
- Framework convention on climate change ,1992(party ratified in 1994)
- The Vienna convention for the protection of the ozone layers
- The Montreal protocol on substance that deplete the ozone layers 1997(party ratified 1991)
- The Stockholm convention on persistent organic pollutants (party ratified in 2004)
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Figure1 show e-waste being processed for recycling in china

III. RECYCLING OF E-WASTE

Considerable quantities of e-waste are now being transported across the globe, more specifically from developed countries to developing countries for unsafe and primitive manual recycling in backyards of residential areas, thereby affecting the environment and human health in these countries. Various researches shows that such practice of recycling in the primitive and manual process contaminate the soil, water and air, besides, such practice have also resulted in the poisoning of many locals, people who are engaged with the recycling process. For instance as reported by Guiyu and Taizhous in China, Gauteng in south Africa, New Delhi in India ,Accra in Ghana, Lagos in Nigeria and Karachi in Pakistan are the largest sites know for recycling of e-waste and this is the same places with higher pollution level as a result of e-waste recycling process. Recycling as a way of managing e-waste is faced with significant challenges including dealings with hazardous materials such as cathode ray tube (CRT) glass and finding markets for flame –retardant plastics. Besides, available statistics indicate that there is serious limitation of technology at present to safely undertake recycling in most developing countries in an environmentally friendly manner. In the year 2005,statistics shows that more than two million tons of e-waste were generated in the united state alone, but only mere 17% to18% of what was collected for recycling informed by the environmental protection agencies ,while the remaining 80% was disposed largely in local landfills. This development can lead to hazardous material in e-waste to leach from the landfills into ground water and streams and if the plastic components are burned, dioxin and other toxic are emitted into the air. In additions to this, there is several research works that shows that nearly 50% to 80% of the e-waste collected for recycling in the US is actually exported to developing countries, even though it is illegal in most of those countries to accept this toxic waste stream. Most of this illegally traded e-waste is going to the informal recycling sectors in many Asian and Western African countries where it is dismantled or disposed of using primitive and crude technologies. (Bhutta et al.2011).

In most of the developing countries, recycling of e-waste take place in the informal sector where people tear apart the different components with their bare hands and without any safety considerations. In some instance, people are using cable waste as fuel for cooking .In fact, people are being exposed to toxic twenty four hours of the day as they live, cook and sleep in the same place where the waste is being recycled. Equally in Asia, life-cycle-analysis is now being applied to estimate the impact of e-waste and e-waste management. In Korea, Kim et al (2004) used LCA to evaluate recycling potential in terms of the environmental and economic factors. The recycling potential in terms of the environmental score showing the highest value was for glass and circuit board followed by iron, copper, aluminum and plastic respectively. In terms of economic score, the result showed the highest value was copper, followed by aluminum, iron, plastic, glass and circuit board. Choi et al (2006) studied the practical recycling rate of an EOL computer and assessed the environmental impact for two disposal method

namely landfill and recycling. Their findings show that recycling is the most efficient option for disposal. Numerous studies conducted on LCA in a number of countries shows that recycling is the most appropriate strategy for many e-waste disposals as compared to landfill or incineration

Figure 2 above show a modern recycling plant in united states.

E-waste is a term for electronic products that have become unwanted non-looking or absolute and have essentially reached the end of their usefulness.

Effects of Chemical In E- Waste on Human Health

E-TOXIN	SOURCE OF E-TOXIN	HEALTH EFFECTS
Arsenic	Found in computer chips and light emitting diodes	Arsenic is known cancer- causing substance (carcinogen), it is known to cause skin and lung cancer
Brominates flames retardants	Added to plastic to prevent fire	Increased risk to thyroid disease and neurobehavioral disease
Cadmium	Cadmium Coating Of Contacts and Switches In the CPU and monitors is used to prevent corrosion. It is found NJCD batteries	Causes damage and death. Cadmium is a known carcinogen
Chromium	Used as hardener in plastics and a dye in the pigments. Present in the coating on some metals	Is a known carcinogen, may cause DNA damage
Halogen	Plastics and insulations	Has possibility that toxins such as dioxin and furans may be created and released burning
Lead	Cathode –ray tubes (about 5ibls) and	Initials symptom of exposures are anorexia, muscle pains, malaise and headache. Long term exposure decreases the wall performance of the nervous system. Prolong exposure cause brain damage and death
Mercury	Old batteries and switches, flat screens have mercury containing fluorescent tubes	Short term exposure to all forms of mercury causes lung damage, nausea, vomiting and increased blood pressure

Solid Waste Related Legilature: The hazardous waste (criminal provision) decree 42 of 1988 The law prohibits the carrying, depositing and dumping of harmful waste on any land, territorial water and related matters. It's prohibit activities relating to harmful waste and lists such activities as:

- The national environment protection (waste management) regulation s.1.25 of 1991, the laws regulate the collections, treatment and disposal of solid and hazardous waste from municipal and industrial sources
- National environment (sanitation and waste control) regulation S.1. 28 of 2009
- Consumers protections council establishment Decree No 66 of 1992

FINDINGS

After exhaustive review of relevant literatures, the following were indentified to be an obstacle to recycling of e-waste or it proper disposal. They include among others:

- Lack of awareness of the danger associated with the improper disposal or rudimentary recycling in the country
- Poor or absent of enforcement by relevant agencies of government
- Inadequate sustainable practice / green procurement
- Non – existence of legislative framework for procurement and used of electronic s in the country
- Lack of purchasing equipment with energy star/ similar labeled vendor with modes actives on delivery
- Promotion toxic reduction

IV. CONCLUSION

Electronic gadgets are complex admixture of several components ,with substantial number of them considered as deadly chemicals .studies have shown that these chemicals are having negative and devastating impact on human health. In view of this e- waste is a national and global problem. E- Waste problems appeared on the onset as a problem of developed countries, but this perception has changed as it becomes a worldwide phenomena. Many case study from e-waste recycling plants confirmed that the toxic chemicals such as heavy metals and POPs have and continue to contaminate the surrounding environments if the end –of –life management is not undertaken meticulously. There are other tools for managing e-waste such as LCA,MFA and MCA which can be used in conjunction with one another or alone, but the fact is that they sometimes overlap with regards to environmental decisions making while each tool has a distinctive features that separate them from EPR. Interactions of the tools can drive to achieve success for e- waste management ,which are developed to be eco-friendly, proper collection, recover and RECYCLE materials by safe method, dispose of e-waste by suitable techniques, forbid the transfer of used electronic devices to developing countries and to raise awareness of the impact of e-waste pollution for both user and manufacturers. Besides, recycling of e-waste may equally generate employment for thousands if modern techniques and methods are used in it.

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